Computer Science
Automobile Guidance with Fuzzy Logic

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In this project, fuzzy logic is used to solve the problem of how to navigate an autonomous vehicle. Based on how far the car veers left or right in degrees, the system will find by how many degrees to turn the steering wheel to adjust the vehicle. In this report we will only present how the fuzzy control works. The use of genetic algorithms to derive the best fuzzy rules possible and their membership functions is discussed.

The following sequence were followed to solve the problem using fuzzy logic:

1) Define the control objectives by knowing what to control, kind of response needed.
2) Determine the input and output relationships.
3) Break the control problem down into a series of IF X AND Y THEN Z rules that define the desired system output response for given system input conditions.
4) Create membership functions for each fuzzy set.
5) Implement in software, or into hardware. (Step 5 will not be included in this project.)
6) Test the system, evaluate the results.

The Fuzzy knowledge Base is a collection of fuzzy rules of the form:
IF (car veers left by a lot) then (turn wheel sharply right)
IF (car veers left a little) then (turn wheel slightly right)

Observations come from attached sensors. For example, the car veers left by 30 degrees. Then fuzzy logic needs to change the fact to a fuzzy set. This is called fuzzification. The fuzzy fact becomes: 0/10 + 0/20 + 1/30 + 0/40

Given the rule IF X is A THEN Y is B, and X is A', a conclusion Y is B' can be reached. It is done as follows:

Given the membership function of A', $m_{A'}$, the membership of the fuzzy set B' is given by:

$$m_{B'}(Y) = \max_x (m_{A'}(X) + m_{A \Rightarrow B}(X,Y) - 1, 0)$$

where $m_{A \Rightarrow B}(X,Y)$ = max (1-m_A(X), m_B(Y))

System Testing:

Test cases were produced by using a model car to reenact the situations of the problem. Some of the results of the test trials are displayed in the following table:

Test Data

Veer left (degrees)	Actual needed wheel turn (degrees)	calculated wheel turn (degrees) by fuzzy system
10	17	20.0
20	19	22.3
30	27	23.3

The comparison shows that the system generates numbers close enough to the actual results. The average error is 15.2%. It is possible that by changing the membership functions of the fuzzy sets (veer left and turn right) the performance of the system will improve even further.